

Capturing Uncertainty in the Common Tactical/Environmental Picture: NRL/Stennis Contributions

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LONG-TERM GOALS

The primary objective of the proposed effort is to use existing science to characterize and represent the uncertainty in the tactical and environmental picture due to uncertainty about environmental features that affect active acoustic detection of submarines.

OBJECTIVES

NRL/Stennis is responsible for providing the best possible estimates of the sound speed, geo-acoustic parameters, and their uncertainties to the other members of the team.

APPROACH

Work is being accomplished by a team headed by APL/UW that includes NRL-SSC, Oregon State University (OSU), ARL-UT, and Metron Corp., all funded under the ONR Capturing Uncertainty Departmental Research Initiative (DRI). NRL-DC is contributing valuable work as well, funded by ONR outside the DRI.

NRL-SSC is providing the best ground truth sound speed profile and geo-acoustic data possible for the geographic area selected for analysis. Initially, the sound speed and uncertainty are being provided by the Modular Ocean Data Assimilation System (MODAS), extractions from a global implementation of the Navy Coastal Ocean Model (NCOM), and extractions from the East Asia Seas Nowcast/Forecast System (EAS_NFS). Models such as NCOM and EAS_NFS include atmospheric forcing effects and

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should be able to represent the near-surface layers more accurately. A baseline geo-acoustic environment for the initial study area was constructed using existing core samples, grab samples, echo sounder data, chirp sonar, seismic data, acoustic data, and representations of the climatological and sedimentary history. This baseline will be used to determine the variations within the local environment that contribute to the creation of acoustic uncertainty and their quantitative value.

EAS_NFS is a version of the Navy Coastal Ocean Model (NCOM) model. This is an automated real-time ocean prediction system that covers a domain from 17°S to 53°N and from 99°E to 170°E. The system uses 26 vertical levels and has 1/8° horizontal resolution. The system produces daily nowcast/forecasts of sea level variation, currents, temperature and salinity for up to 72 hrs. The system is restarted everyday from previous nowcast fields. It continuously assimilates MODAS synthetic temperature/ and salinity fields based on sea surface height anomaly from satellite (GFO, TOPEX/Poseidon, ERS-2), and (AVHRR) sea surface temperature. It is forced by NOGAPS wind stress, surface heat fluxes and surface air pressure. It uses realistic coastlines and bathymetries.

To address the scales required for the internal wave frequencies of interest in these studies, non-hydrostatic models will be required. We are using 2D (Lamb and U. of Hamburg) and 3D (Smolarkiewicz and Potts) models with simplified coastlines and bathymetries (at present) to conduct simulations of Yellow Sea.

WORK COMPLETED

For the initial phase of the project, the team chose a time and region of the world to begin modeling that corresponds to a representative tactical exercise. This exercise took place in the East China Sea during July and August of 2000 in an area just west of the Ryukyu Trench. This site was chosen both for its tactical relevance, reasonably uniform geo-acoustic environment, and the availability of active sonar data. A particular event that took place during the exercise, involving a diving and resurfacing submarine, that provides an especially useful collection of continuous wave (CW) and wide-band acoustic data. This will be used as the starting point for our investigations.

A medium detail geo-acoustic map of the ECS site was created using a combination of direct measurements, existing interpretations of the geologic history and geophysical data. The validity of the map was checked by inversion of transmission loss from acoustic exercises in the area. The variation in layer thicknesses was estimated using core-hole data, and echo sounding data.

MODAS and measured sound speed profiles for the area, along with a range of expected values for that location and time of year were provided and used as initialization seeds for the internal wave model run by OSU.

Nowcast/Forecasts from the EAS_NFS were compared with temperature fields extracted from MODAS and with temperature fields from AXBT surveys for August of 2000. During this period there was no data assimilation in the EAS_NFS. The EAS_NFS started assimilating data in 2001. We compared the temperature fields from the EAS_NFS with MODAS for August of 2001. Unfortunately there were no AXBT temperature fields available for that period. All the comparisons were done with vertical cross-sections because the vertical variation of temperature has a strong impact on the acoustical field. However, the horizontal variability of the temperature field also significantly affects the acoustical field. That is particularly apparent in some of the nonhydrostatic results dealing with solitons.

RESULTS

The medium resolution geoacoustic map agrees with the exercise data within the experimental error of the data (claimed at 3 dB), although it is not that the actual error in entire site would be within that range. The variation in thickness of the surface layer seems large enough to account for most of the variability in the data. However, variation in horizontal is being examined and vertical material are being re-examined to verify the original estimates.

The MODAS estimates of sound speed were compared to in situ profiles. Although the comparison was quite good in general, the near surface (sonic layer depth) was less well represented, due to the fact that MODAS does not include the effects of the winds. The EAS_NFS simulations produce realistic T and S fields for moderate to large amplitude internal waves and other large aspect ratio features. We are continuing to improve our treatment of bathymetry and of sources of internal waves.

The EAS_NFS produced realistic temperature fields that agreed well with MODAS and AXBT temperature fields. In 2000, without data assimilation, the MODAS and EAS_NFS results were in excellent agreement and both captured major aspects of the temperature variability seen in the fields from the AXBT surveys in both north-south and east-west sections (Figure 1). In 2001 with data assimilation there was also good agreement between MODAS and EAS_NFS; however there were some differences in the location and intensity of some features. Unfortunately no AXBT surveys were available for this period. Although the $1/8^\circ$ resolution is too coarse to capture the details of the internal wave field desired for this study, higher resolution nests set within the EAS_NFS could resolve the temperature field in enough detail for small to moderate amplitude internal waves and other small aspect ratio features.

IMPACT/APPLICATIONS

Results of the team's work will apply to numerous Navy acquisition programs. Virtually all Navy Tactical Decision aids used in air, submarine, and surface ASW and MCM communities will, in time, be modified to include methods developed from this program to quantify and represent to fleet operators the uncertainty of estimations of sensor performance. Results of the program will improve the ability of Navy personnel, from sonar system operators to battle-group staff commanders, to understand how well their systems are working and how best to employ them. These results will similarly be used to provide environmental sampling recommendations to reduce uncertainty in critical parts of the battle space.

TRANSITIONS

SIIP, STDA (surface and submarine), TAMDA, SPPFS, MEDAL, CUP, TDA IV&V, NITES

RELATED PROJECTS

1. Nonhydrostatic Coastal Ocean Dynamics (NRL 6.1 Core)
2. End-to-End Predictions of Focusing Deep Acoustic Energy by a Shelf/Slope Front (NRL 6.2 Core)

3. Prediction of space-time acoustic coherence for non-stationary, anisotropic shelf and shelf-break littoral environments (NRL 6.2 Core)
4. MODAS Improvements (ONR 6.2)
5. On-Scene Tactical Ocean Forecast System (SPAWAR 6.4)

PUBLICATIONS

Fulford, J. "Some Effects of Thin Relic Surficial Sand on Bottom Interaction.", Acoustic Letters (submitted)

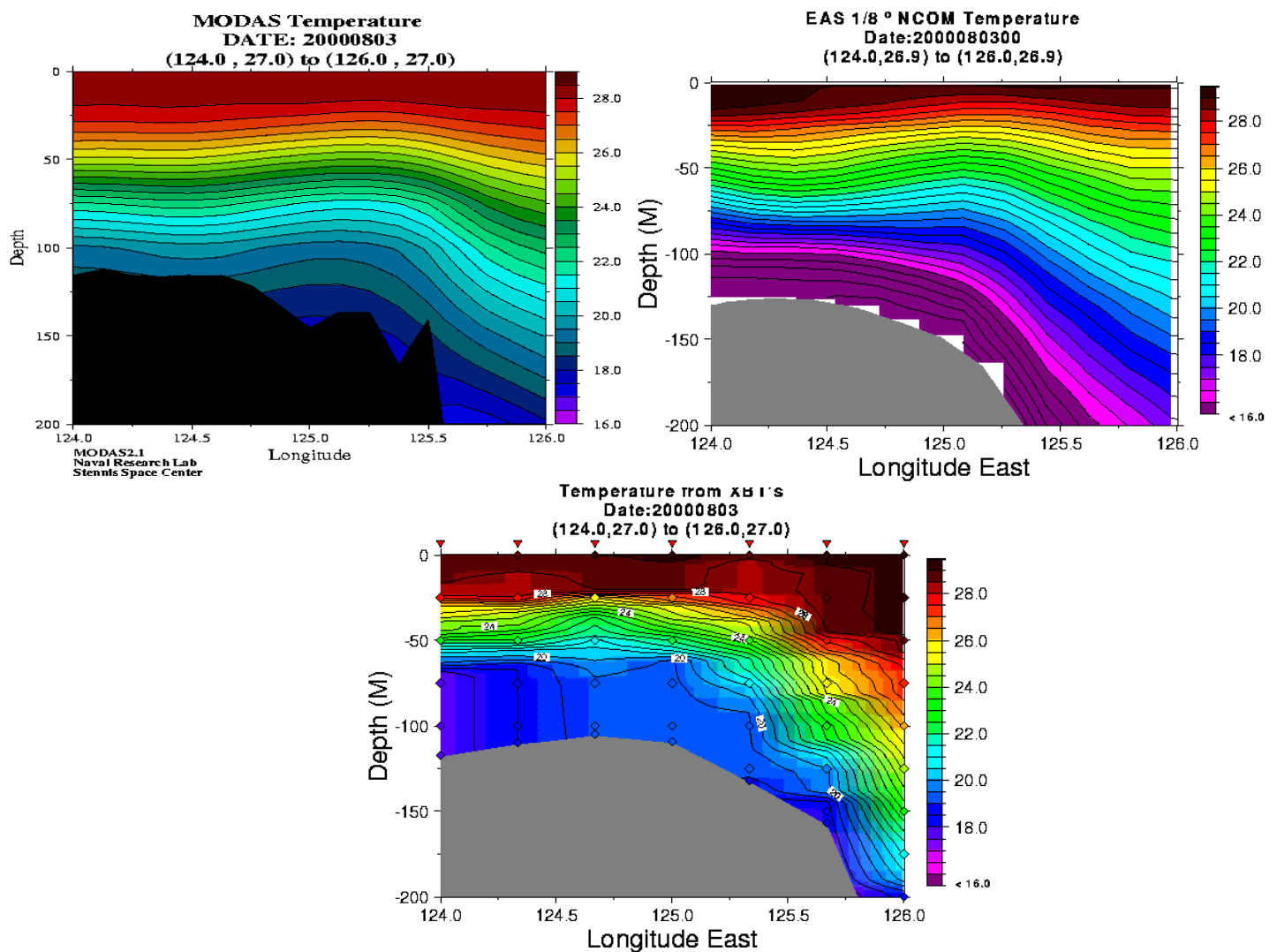


Figure 1. Longitudinal-Vertical Cross section of temperature from MODAS, EAS_NFS and AXBT surveys through the exercise area.